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ABSTRACT

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Cumulative deficit is an hypothesis concerning the cause of lower mental test scores of groups considered environmentally deprived. It presupposes a progressive decrement in test scores, relative to population norms, as a function of age. Clarification of the theoretical issues and the methodological problems involved in establishing the progressive decrement phenomenon are discussed in relation to the relevant research on disadvantaged groups, especially American Negroes. In this group in particular there is no methodologically adequate evidence in the literature for a progressive decrement in IQ or other mental measurements. The present study, using differences between younger and older siblings, which satisfies rigorous methodological requirements for the detection of progressive decrement, found a slight but significant decrement in Verbal but not in Nonverbal IQ among a large sample of Negro elementary school children. The same method detected no progressive decrement in the white school population.

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Cumulative Deficit: A Testable Hypothesis?[1]

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The term cumulative deficit refers to one of the most furdamental concepts in the now vast literature of environmental deprivation and cultural disadvantage. It is also the keystone of the rationale for compensatory education.

The apparent phenomenon which the cumulative deficit hypothesis attempts to explain has long been recognized, as in Gordon's (1923) striking finding of large IQ decrements with increasing age of educationally deprived canal boat children in England. But the term itself is fairly recent. As far as can be determined, it is attributable to Otto Klineberg (1963), who, in attempting to explain intellectual differences between races, remarked that "it is as the children get older that differences in test performance appear. Surely this is to be expected on the basis of the cumulative effect of an inferior environment"(p. 200). As an example of this phenomenon, Klineberg cited a study by Sherman and Key (1932) of white children living in the "hollows" of the Blue Ridge Mountains, where the average IQ declined from 84 at ages 6-8, to 70 at 8-10, to 53 at 10-12! Following Klineberg's 1963 article, the concept of cumulative deficit rapidly proliferated in the growing literature on cultural deprivation. The term is used extensively, for example, in a review of 99 research reports on the disadvantaged published within four years after Klineberg's article (McCloskey, 1967). In this review, as generally elsewhere in the literature, cumulative deficit stands both for the purported phenomenon of an

increasing decrement in test scores with increasing age of disadvantaged children relative to advantaged children, and for the hypothesis which explains this phenomenon in terms of the cumulative effects of a deprived environment. We read, "Both history and the modern science of aptitude measurement indicate that the relatively limited capabilities and achievements of disadvantaged pupils are due mainly to restrictions of external environment, not to their internal potentials. Regardless of how 'intelligence,' 'aptitude' and 'achievement' are defined, research provides ample evidence that, at present, inadequate and inappropriate schooling is largely responsible for stultification of many capacities" (McCloskey, 1967, p. 4). "Such deficits of development and learning are cumulative. They progressively reduce the emotional and cognitive bases essential for normal rates of acquiring more complex concepts and capabilities. Consequently, as years pass, disadvantaged children tend to become progressively more retarded" (McCloskey, 1967; p. 6).

More detailed explications of the cumulative deficit concept are presented in the writings of Martin Deutsch, a leading researcher on the culturally disadvantaged and early childhood compensatory education. He refers to cumulative deficit as ". . . the decline over time in their [i.e., experientially deprived children's] scholastic achievements and in measures of 'intellectual abilities'" (Deutsch, 1967, p. 338). More specifically, "it appears that, as Negro children get older, the discrepancy between their IQ scores and those of white children increases, while the discrepancy between the two groups' scores on the language measures of this research decreases. At the first-grade level, the disadvantaged child's experiences seem to have been relatively sufficient to provide him with certain language skills. By the fifth grade, however, he does not seem to have had the background of experiences in the use of the more complex language necessary both for success on

intelligence tests and for expressing himself meaningfully in complex sentence structure" (Deutsch et al., 1967, p. 221). In support of the cumulative deficit hypothesis, Whiteman and Deutsch note that in their own study the magnitude of the decrement in Lorge-Thorndike IQ with age is greater for those children who score as most disadvantaged in the specific experiences assessed by a Deprivation Index, and the age decrement is even greater for the WISC Vocabulary Test. "The general tenor of these results points to the greater sensitivity of the language test to different patterns of disadvantage, whether these disadvantages are related to general socioeconomic level or to Negro status, or to the specific background factors implied in the Deprivation Index" (Deutsch, 1967, p. 345). That the cumulative deficit is the basis of the rationale for compensatory education is suggested by statements such as ". . . in order to arrest the cumulative-deficit process and to go beyond that by actually reversing deprivation effects and carrying performance levels up to national-norm expectations, more potent interventions along the lines discussed will be necessary" (Deutsch, 1967, p. 27). And ". . . it would seem reasonable to conclude that if learning sets or the level of underlying abilities are influential in a decline in performance, an improvement of these skills through an enrichment program at the preschool and kindergarten levels may be helpful in arresting or reversing the cumulative deficit" (Deutsch, 1967, p. 338).

The cumulative deficit hypothesis has been put forth in what is perhaps the most explicitly testable form by a sociologist, who likened the cumulative effects of the environment on cognitive development to a compound interest table (Stincombe, 1969, p. 518). For example, if two groups differ, on average, by x percent per year in rate of mental development because of differences in environmental inputs, the cumulative (i.e., "compound interest") effect would decrease the ratio of the disadvantaged/advantaged group mental age means by more and more each year. This model clearly implies not only an increasing mental age difference but also an increasing IQ difference between the groups, from early childhood to maturity, with its corollary of a negative correlation between IQ and chronological age in the environmentally disadvantaged group.

Empirical Evidence

Though the earliest mentions of the phenomenon involved IQ decrements in children on English canal boats and in Tennessee mountain "hollows," the greatest use of the cumulative deficit concept in recent years has been in connection with the lower performance of Negro children relative to white children on tests of intelligence and scholastic achievement. Yet, surprisingly,

it is difficult to find consistent or satisfactory empirical evidence of ability decrements increasing with age in Negroes relative to whites. There is even a question whether the phenomenon which the cumulative deficit hypothesis is intended to explain actually exists, at least in the Negro population, where cumulative deficit has been so prominent a part of the explanation of Negroes' generally lower IQ and poorer scholastic achievements.

Leona Tyler, in the section on Negro intelligence in her well known text-book on human differences, mentions cumulative deficit, noting that ". . . the higher the school grade in which the [IQ] tests have been given, the greater the difference between Negro and white averages has turned out to be" (Tyler, 1965, p. 306). She cites the Negro norms for the Stanford-Binet Intelligence Scale obtained on some 1,800 Negro children in five Southeastern states by Kennedy, Van De Riet, and White (1963). Based on groups of Negro school children from 5 to 16 years of age, the results of this study are indeed striking. From age-group 5 years to age-group 16 years the mean Stanford-Binet IQ declines steadily from 86 to 51 (with an overall mean of 80.71). Such a finding would be impressive if it were not for highly likely artifacts that could account for these results. The data are a cross-sectional sampling of IQ's at various age levels and not a longitudinal picture of IQ changes in the same group of subjects as they advance in age. Such cross-sectional studies of IQ decrement can introduce selective sampling biases which give the appearance of IQ decrement even when no such decrement exists as a psychological phenomenon in individuals. For example, all 1,800 children in the study by Kennedy et al, although ranging in age from 5 to 16 years, were selected from grades 1 through 6. Consequently, the youngest children (under age 6) are under-age for first grade and are more likely to be intellectually advanced for their years; they are thus an unrepresentative sample of five-year-olds. At the other extreme,

children in Grades 5 and 6 who are beyond 11 or 12 years of age are also atypical, in the opposite direction; the over-age children in the later grades are more likely to be retarded to some degree in their intellectual development. This relationship between "over-ageness" and decline in mean IQ of cross-sectional age samples was clearly demonstrated in an early study by Wheeler (1942). These biasing artifacts due to the method of sampling could well account for the apparent increasing IQ deficit in the study by Kennedy et al. Kennedy himself suspected this artifact. To check this possibility, he carried out a longitudinal study of a representative sample of one-sixth of the subjects in the original study (Kennedy, 1965). The longitudinal sample (N = 316) was retested on the same Stanford-Binet five years later and showed no decrement whatsover in mean IQ (78.9 versus 79.2). The cross-sectional data had indeed been misleading in respect to the cumulative deficit hypothesis.

Not all cross-sectional studies have found an increasing difference between Negro and white IQ's. In samples from rural Virginia, for example, Bruce (1940) found no greater decline in Negro than in white IQ's in the age range 6 through 12, though both groups showed a cross-sectional decline of about 10 points over this period and both groups overall had below-average Binet IQ's (white = 90, Negro = 76).

Shuey (1965, pp. 206-7) has examined all the relevant studies on this point up to 1965. She compared all the mean IQ's of Northern and Southern Negro elementary school children of ages 6 to 9 with the IQ's of other Negro children in the same regions, ages 10 to 12. There were 19 studies in all, totalling some 9,350 children. The mean IQ of the younger group was 84.03; of the older group, 82.98. Since in many schools education was not compulsory until 7 years of age, Shuey suspected that the presence of six-year-olds in the younger age group might have biased the mean IQ upwards, since these six-year-olds would tend to be more intellectually advanced than their age-mates.

When the 710 six-year-olds were excluded from the younger group, its mean IQ was reduced to 83.33, or just 0.35 above the mean of the 10 to 12 year group. Shuey also compared IQ's of Negro children in Grades 1 to 3 with those in Grades 4 to 7, reported in a total of 43 studies comprising some 19,000 Negro children. The mean IQ's of the earlier and later grades were 83.11 and 84.54, respectively. Shuey also examined the IQ results for Northern and Southern Negroes separately and found no interaction with age. She concluded, "It seems, therefore, that between the ages of 7 and 12 and between grades one and seven there is a marked stability in the IQ of colored children enrolled in the public schools" (Shuey, 1965, p. 207). A serious limitation to Shuey's conclusion is that no account is taken of the probably different school dropout rates with advancing grade level in the white and Negro populations. If dropouts increase at a faster rate in the Negro group, and if dropouts come largely from the lower half of the IQ distribution, the effect of such differential selection would be to diminish or prevent the appearance of a Negro age decrement in IQ.

The most massive collection of relevant cross-sectional data is to be found in the well-known Coleman report (Coleman et al., 1966), in which 450,000 children in Grades 1, 3, 6, 9 and 12 in 6,000 schools across the nation were given tests of verbal and nonverbal ability and of scholastic achievement. Except in the southern regions of the U. S., the Coleman data indicate a fairly constant difference of approximately one standard deviation (based on whites in the metropolitan northeast) between whites and Negroes in Verbal Ability, Reading Comprehension, and Math Achievement from grades 6 to 12. In the non-metropolitan South, on the other hand, the mean Negro-white differences in Verbal Ability are 1.5, 1.7, and 1.9 SDs in grades 6, 9, and 12, respectively (Coleman, et al., 1966, p. 274). This suggests an increasing deficit in the Southern

Negroes, but cannot prove it, since these cross-sectional data could reflect selective migration of families of abler students out of the rural South, thus causing an increasing accumulation of poorer students in the higher grades.

Moreover, the populations of the rural South and of the Metropolitan North differ in average family size, and family size is negatively correlated with IQ. The apparent age decrement in IQ among Southern Negroes could therefore reflect merely regional differences in family size. This artifact in cross sectional studies is discussed more fully in the next section which deals with methodology.

Probably the most carefully selected and representative cross sectional age date on mental tests in U. S. White and Negro children between ages six and twelve are those obtained by the National Center for Health Statistics from 1963 to 1965, as part of the National Health Survey (Roberts, 1971). A total probability sample of 7,417 children, with approximately 1,000 in each year's age group between ages 6 to 12, was selected so as to be "closely representative of the roughly 24 million noninstitutionalized children 6-11 years of age in the United States" (Roberts, 1971, p. 2). Two subtests (Vocabulary and Block Designs) of the Wechsler Intelligence Scale for Children (WISC) were individually administered to 96 percent of the sample. From the raw score means and standard deviations for Negroes and Whites in each of six age groups (presented in Table 4, p. 31), it is possible to determine the mean White-Negro difference in σ units at each age, and separately for boys and girls. (The σ in this case is the average of standard deviations within each racial group.) A systematic increase in the White-Negro difference with increasing age is best determined from the regression of the mean differences on age. If the slope of the regression $\underline{b}$ is significantly greater than zero, it means there is a significant increase in the White-Negro mean difference (in σ units) with increasing

age. On the WISC Vocabulary, for both sexes combined, $\underline{b}$ = + .025, $\underline{t}$ = 2.49, $\underline{p} < .05$; for boys, $\underline{b}$ = .017, $\underline{t}$ = .78 n.s.; for girls, $\underline{b}$ = .060, $\underline{t}$ = 3.43, $p < .05$. (In all cases $\underline{df}$ = 5.) These regressions are very small; the largest (.060) means that the White-Negro IQ difference increases only six one-hundreths of a standard deviation each year from age six to eleven. Yet for these data the effect is significant--for girls but not for boys. However, the sex difference between $\underline{b}$'s is not significant. The same trend is true of the WISC Block Designs. For both sexes combined, $\underline{b}$ = .051, $\underline{t}$ = 5.94, $\underline{p} < .01$; for boys, $\underline{b}$ = .053, $\underline{t}$ = 1.51 n.s.; for girls, $\underline{b}$ = .068, $\underline{t}$ = 5.55, $p < .01$. Though the $\underline{b}$ is significant for girls but not for boys, the difference between the $\underline{b}$s of boys and girls is nonsignificant. The overall mean White-Negro difference is .78 σ for Vocabulary and .76 σ for Block Designs. For boys the corresponding differences are .81 σ and .78 σ, and for girls, .75 σ and .75 σ. So despite considerable mean differences, the evidence of Negro age decrement is slight. But little stock can be put in this evidence since it is cross sectional data, and although it is a most carefully drawn probability sample, such sampling confounds age, IQ, and family size, so that some degree of age decrement in Negro mean scores relative to the White would be expected as a demographic artifact. It may not reflect a psychological or developmental phenomenon. This is explained in the next section on methodology.

One of the most thorough comparative studies of Negro and white children in the rural South (North Carolina) is by Baughman and Dahlstrom (1968). They examined their test data with respect to cumulative deficit by cross-sectionally comparing Negro and white samples at one-year age-intervals from 7 to 14 years

of age on Stanford-Binet IQ. The Negro IQ's were almost constantly one SD below the white IQ's from age 7 to 14, although the gap narrows slightly after age 11 due to a lowering of the white IQ by some 3 to 4 points. (The whites in this study are below the average white norms, with a mean in the 95 to 100 range.) An analysis of variance of the Baughman and Dahlstrom (p. 45) data show a significant decline in IQ with increasing age for white boys and girls, and for Negro boys, but not for Negro girls. In all groups the effect is small in any case. Other ability tests used in this study illustrate the high degree of specificity of the age deficit. For example, the various subtests of the Primary Mental Abilities: some tests do, others do not show a decrement, and still others show the reverse of the hypothesized age decrement (Baughman & Dahlstrom, 1968, pp. 48-57). There seems to be no consistent trend according to the type of mental ability measured by the PMA tests, although the authors (p. 46-7) entertain the notion that the decrement sets in as language proficiency becomes an increasingly important factor in the test. This opinion has also been emphasized by Deutsch (1967, p. 331). Yet the vocabulary raw scores of both the Negro and white samples show an almost perfectly linear increase with age over the range from 7 to 14 years, thus revealing no decrement effect. The fact that the verbal requirements of most mental tests increase at higher age levels is confounded with the increasing degree of abstractness of the item content and the complexity of the mental operations called upon. The increasing deficit, if indeed it actually exists, could be more a lag in conceptual development than in verbal proficiency per se. Also, as in other cross-sectional studies, family size was not controlled. Older children, on the average, have more siblings, and larger families have slightly lower IQs, so that a cross-sectional study based on the comparison of IQs of younger and older age groups confounds the possible effects of age decrement in IQ with the statistical effect of family size.

Some of the Baughman and Dahlstrom data lent itself to longitudinal analysis (p. 112). The overall Stanford-Binet IQ change over a three-year period was -1.1 points for Negroes and +0.6 points for whites, making for a net Negro decrement of 1.7 IQ points. There was some interaction of this with sex; girls, especially in the Negro group, showed little or no decrement.

Another longitudinal study in the rural South (Georgia) showed no overall decline in mean IQ from Grade 6 to 10 for either Negro or white students, who differed by a constant amount of approximately 20 IQ points (Osborne, 1960).

A longitudinal study in the North, by Harris and Lovinger (1968), obtained intelligence and achievement test scores on the same group of disadvantaged Negro and Puerto Rican (in the ratio of 10 to 1) pupils in Grades 1, 3, 6, 7, 8, and 9. (The junior high school attended by these children had the lowest average achievement of any in the borough of Queens, New York.) There was no evidence of a declining IQ in this group, i.e., the 8th and 9th grade IQs were approximately equal to the first grade IQs.

Still another longitudinal study compared groups of Negro and white pupils at two-year intervals from Grades 5 to 11 on a battery of scholastic achievement tests (Sequential Tests of Educational Progress [STEP] and School and College Ability Tests [SCAT]) (Rosenfeld & Hilton, 1971). When the means of later tests were adjusted by covariance on scores obtained two years previously, the Negro-white gap remained constant across age on some tests but still increased on others. Tests that showed increasing Negro decrements relative to whites, even after covariance adjustment on initial status, were SCAT Verbal and Quantitative and STEP Math as well as STEP Writing (at 9th grade only). Between Grades 9 to 11, Negroes and whites grew at about the same rates (after covariance adjustment on previous scores) on Reading, Writing, Social Studies, and Listening.

The authors suggest that differences in the curricula of their Negro and white samples are most likely to account for the observed increase in the Negro-white gap from Grade 5 to Grade 11. The majority of whites were in the academic program while the majority of Negroes were in the nonacademic program. Rosenfeld and Hilton rightly comment: "The content areas which these tests assess may be ones to which academic and nonacademic students are differentially exposed, thus accounting for the differences observed. In addition, curriculum membership in itself is a complex interaction of self-selection, counselor judgment, and school policy. The observed differences are, therefore, as confounded as school differences and the researcher is left with results to be explained rather than tested hypotheses" (p. 281).

In addition to cross-sectional and longitudinal studies, there is one other method for investigating cumulative deficit: comparison of younger and older siblings. This method, which has certain distinct advantages (detailed in the following section), has been used, but not optimally, in only two studies of cumulative deficit. The logic of the method is clear: younger and older

full siblings within a given family do not differ, when averaged over many families, in genetic potential for mental development. Each child in a family receives a random allotment of one-half of his parents' genes, and the ordinal position of his birth in no way affects this fact. Any systematic difference between younger and older siblings, therefore, must be attributable to non-genetic, presumably environmental, influences or to genetically conditioned differences in developmental rates. Significantly lower IQs (or other age-standardized scores) of the older than of the younger sibs, on the average, should therefore constitute strong evidence of a genuine deficit (assuming control of certain other conditions to be mentioned later), whether genetic or environmental or both, rather than merely a result of sampling artifact such as we have seen in cross-sectional studies and as can occur in longitudinal studies that have nonrandom attrition of subjects throughout the course of the study, which is nearly always the case.

Gordon (1923), in England, was the first to use sibs to show that Stanford-Binet IQ fell with age in educationally deprived canal boat children. The mean IQ of the youngest child in these families was 90, of the second youngest 77, of the third youngest 73, and of the oldest 60.[3] This particular use of sib data, however, is far from ideal, since, when we compare average IQ's of the first, second, third,etc. child in a family and do not explicitly control for family size, we confound two variables--younger vs. older and family size; the first is the variable in question as regards the cumulative deficit hypothesis; the second variable is already well know to be negatively correlated (about -.30) with IQ (Anastasi, 1956; Baughman & Dahlstrom, 1968, pp. 100-1). Thus, Gordon's finding may simply reflect in part the fact that four-child families have a lower mean IQ than three-child families, and three-child families have a lower mean IQ than two-child families. In the entire group of Gordon's canal boat subjects, there was a correlation of -.76 between IQ and chronological age. The existence

of intrafamily sib differences associated with children's ordinal position in Gordon's data, however, indicates that not all of the difference between the means of first, second, third, etc. children can be attributable to the negative correlation between IQ and family size. But the analysis does not sufficiently unconfound these two variables to permit any strong quantitative conclusions about the magnitude of the IQ age decrement *per se*.

Baughman and Dahlstrom (1968, pp. 102-3) found a relationship between sibs' ordinal position and Stanford-Binet IQ, but it involved a complex interaction with race, sex, and age; there was no consistent or statistically significant tendency in either the white or Negro samples for the younger sibs to score higher than their older sibs, as would be expected from the cumulative deficit hypothesis. In fact, slightly the opposite was the case, with the older sibs showing a slight superiority. As in Gordon's study, Baughman and Dahlstrom present their family data in terms of mean IQ for children in various ordinal positions (classified into 3 categories: youngest, oldest, intermediate), and they arbitrarily assigned singletons to the category of oldest children, thus again confounding IQ age decrement and family size. Such an analysis is of little or no value in determining the existence or magnitude of the decremental effect which the cumulative deficit hypothesis aims to explain.

Theoretical, Psychometric, and Methodological Considerations

First, a clear distinction must be made between cumulative deficit as a psychological *hypothesis* and the empirical *phenomenon* which the hypothesis purports to explain. This important distinction has not been at all clear or explicit in the literature. The distinction is important because, scientifically, the hypothesis is, of course, needless unless there is actually a phenomenon to be explained. The importance of the hypothesis also will depend to some extent upon the

magnitude of the phenomenon in relation to other related phenomena, such as the magnitude of the overall average Negro-white difference in IQ and scholastic achievement. Therefore, we should look first at the phenomenon itself, and at the methodological problems involved in establishing its existence.

To distinguish the phenomenon from the hypothesis, the writer originally proposed the term "progressive achievement decrement" (Jensen, 1966), or "progressive achievement gap" (Jensen, 1971). These terms seemed to be merely descriptive of the phenomenon and, unlike the term cumulative deficit, are not laden with any theoretical overtones as to its cause. But the word "achievement" in "progressive achievement decrement" or "progressive achievement gap" also seems insufficiently neutral for a scientific descriptive term, and simply the term progressive decrement now seems preferable. It would be more complete and more accurate to say "progressive rank order decrement" or "progressive standard score decrement," since the phenomenon does not consist of a loss or progressive decrement with age in the absolute amount of anything (as may well be the case in old age and senility), but consists of an individual's or a subpopulation's progressive loss in relative standing or rank (as reflected in an age-standardized score) among age-mates with increasing age during the period from early childhood to maturity. For brevity, however, we will continue to use the term progressive decrement.

The cumulative deficit hypothesis was made explicit as follows: "All learning beyond the first few weeks or months of life depends upon previous learning. Knowledge and ability develop in a hierarchical fashion; the development of each new level is facilitated by transfer from earlier learning. More complex forms of learning build on simpler forms of learning. When the

habits, skills, or cognitive structures that are prerequisite for some 'new' learning have not been fully acquired, the capacity for the new learning will be impaired: learning will be retarded, inefficient, incomplete, or even impossible, depending upon the degree of inadequacy of prerequisite skills. Since learning builds on previous learning, weakness at any stage creates still greater weakness at later stages. Because subsequent learning depends upon transfer from prior learning, learning deficits are cumulative. Thus the term cumulative deficit" (Jensen, 1966, pp. 40-41). It has been assumed that the cumulative deficit in scholastic achievement occurs in many environmentally disadvantaged and minority children because at the time of school entry they have acquired fewer of the prerequisite skills for school learning than are possessed by the majority of their middle-class age-mates.

The counter hypothesis holds that the progressive decrement of low SES children is not in the main a matter of learning and transfer, but a matter of a different rate of development or a different growth function of the intrinsic maturation of cognitive abilities and their neurological underpinnings. The two hypotheses are, of course, not mutually exclusive. Both kinds of causes, extrinsic and intrinsic, could be operating simultaneously. Then the task of investigation would be to disentangle them and weigh their relative contributions to the progressive decrement phenomenon. The present study, however, does not attempt anything so ambitious as that, but instead focuses on the prior question of whether a progressive decrement can even be shown to exist in any minority school-age population in the United States, for as we have seen, the evidence to date is not at all conclusive on this point. Methodological shortcomings and the likelihood of overriding artifacts make the existing evidence for progressive decrement in the U. S. Negro population highly dubious.

But now let us first be clear about what is not meant by progressive decrement. It does not mean only

the increasing spread with age between the raw test scores of individuals with initially average (or above average) scores and of individuals with initially below average scores. This phenomenon is nearly always observed for raw scores on tests as well as for Mental Age (which is obtained from the regression of raw scores on chronological age) and for Grade Equivalents (the regression of raw scores on school grade in months or some other fraction of a year). Nearly all mental ability and achievement tests in the age range from 5 or 6 to 14 or 15 show a more or less linear increase in raw scores with increasing age, and generally there is a constant proportion between the standard deviation and age. This fact underlies the relative constancy over the years from 5 to 15 of ratio scores such as the IQ and the EQ. The regularly increasing standard deviation of raw scores from early to later ages is characteristic of virtually all growth characteristics, physical as well as mental. Thus, in the absolute units of physical measurement (e.g., height and weight) or in the raw score units of aptitude and achievement tests (which are at best only an interval scale and usually only a more or less normalized ordinal scale) there is an increasing gap from younger to older ages between the scores of the upper and lower halves of the distribution. If this gap at each age is divided by the SD at the corresponding age, the gap (now in sigma units) may or may not remain constant over the age range. It is only when there is an increasing gap between the means of two subpopulations as expressed in sigma units that we have potential evidence of a progressive decrement. If the increasing gap exists only for the raw scores (or the derivative MA and Grade Equivalent), while the gap in sigma units is constant across age, it means that the members of the subpopulation with the lower overall mean do not show any more progressive decrement than do those members of the higher subpopulation who have the same initial scores as the members of the lower subpopulation.

No ¶ As was noted in the Coleman report (1966, p. 273), ". . . the lag of Negro scores (in Verbal ability) in terms of years behind grade level is progressively greater. At grade 6, the average Negro is approximately 1-1/2 years behind the average white. At grade 9, he is approximately 2-1/4 years behind the average white. At grade 12, he is approximately 3-1/4 years behind the average white." The report then notes that the difference (in metropolitan Northeast) is constant in number of standard deviations: "Thus in one sense it is meaningful to say the Negroes in the metropolitan Northeast are the same distance below the whites at these three grades--that is, relative to the dispersion of the whites themselves." The report illustrates this by pointing out that at Grade 6 about 15 percent of whites are one SD, or 1-1/2 years, behind the white average; at Grade 12, 15 percent of the whites are one SD, or 3-1/4 years behind the white average.

Though the absolute or raw-score gap is not the main point of theoretical interest in terms of the cumulative deficit hypothesis, it is the absolute gap which is so readily perceived by teachers and parents, and it becomes increasingly obvious at each higher grade level. Children who are one standard deviation below the average are hardly distinguishable in kindergarten or first grade, while an achievement lag of one standard deviation at high school age is uncomfortably conspicuous to everyone, often being equivalent to three or four grade levels below the average for the student's age.

One point in the statement from the Coleman report quoted above is apt to be misleading, i.e., saying that Negroes are the "same distance" below the whites at grade 6, 9, and 12. "Distance" implies an amount of something, that is, measurement on an absolute scale, like height and weight. This we surely do not have in the psychological tests used in the Coleman study or, for that matter, in the tests used in any study that is at all relevant to the progressive decrement phenomenon. All that our test scores (either raw scores or standardized

scores) at any given age really represent is an individual's relative standing among the total group. At best, we can make a pretense of having an interval scale (but never an absolute scale which is distinguished by a true zero point on the trait) by assuming that individual differences in the trait in question are the result of a number of small, independent, additive effects, therefore being normally distributed in the population, and then "normalizing" our standardized scores, a procedure which mathematically forces them into the so-called Gaussian or bell-shaped curve. (IQs in most modern intelligence tests are just such a scale.) Nothing really is lost by doing this, and probably nothing much of any psychological significance is gained from this procedure of converting standardized scores (i.e., deviations of raw scores from the mean, expressed in sigma units) into ranks, which are in turn converted (via percentile ranks) to normalized standardized scores. But some statistical conveniences may be gained thereby; if per chance our assumption of normality of the population distribution of the trait is correct, we have the added advantage of a true interval scale of measurement, so that a difference in one part of the scale is equivalent to the same numerical difference in another part of the scale in terms of whatever the scale happens to measure.

If we look at standardized scores, in which the mean and standard deviation are made exactly the same at every age level, we will notice changes across ages in individuals' standardized scores. That is to say, there will be changes with age in individuals' position in relation to the position of others in the group, unless, of course, there is perfect correlation of the scores at each age with the scores at every other age. But this never pertains in actual longitudinal data. The universal finding of a decreasing correlation between scores as the age interval between tests increases, from early childhood to maturity, means that individuals are shifting in position across age.

No ¶ If we should select out a subsample of older children or young adults all with below-average scores at their present age and were able to trace back their scores on the same (or similar) tests at each previous year, we would find that these individuals for the most part had steadily declined in their relative position. Some would have had average or above-average scores to begin with. We could say that this group of low-scoring adults had shown a progressive decrement throughout their development, whatever the cause. And if we picked a group of high-scoring adults, we would find the same thing, but in the opposite direction; their scores at each age from childhood to maturity by and large would have steadily increased. Conversely, if we pick a group of low-scoring subjects in early childhood, their scores on the average will gradually rise over the years. By the same token, high-scoring pre-schoolers will show a gradual decline over the years. This is all familiar as "regression toward the mean."

But some of the observations involving groups may seem rather puzzling at first glance. For example, if one selects from among upper-middle class white children entering kindergarten a group of low scorers, all of whom test below IQ 100 with a mean of, say, 90, and follows these children longitudinally with yearly tests all the way up to high school, one will find a marked steady rise in the average IQ of the group. By age 16 or 17 they will probably average close to 110. If, on the other hand, one takes a group of low SES Negro kindergartners with the same mean IQ of 90 and follows them to high school, their IQs, on the average will show an opposite trend; they will decline to about 85. In the one case there is a progressive increment; in the other, a progressive decrement. The cause of this phenomenon is another question altogether, which this article does not attempt to answer. The empirical fact, however, is that each of the two groups just described, even when selected in the same manner and from the same school, show regression toward the final

(i.e., high school age) means of the subpopulations from which they were selected. This was demonstrated by Osborne (1960) in a longitudinal study of IQ and scholastic achievement scores, in which the means of extreme groups (lower third and upper third) of Negro and white children tested at grades 6, 8, and 10 each showed convergence toward the means of their respective populations rather than toward a common 10th-grade mean.

The same thing would happen if one compared groups of upper and lower SES white children. The mean IQ of kindergarten children averaging IQ 100 in a low SES white neighborhood will show some decline over the years; the mean IQ of kindergarten children averaging 100 in a high SES white neighborhood will show some rise over the years. At least in theory, the total regression may be analyzed into regression toward a number of different values, the algebraic sum of which is the value toward which the regression effect converges. The individual's obtained score converges toward his own "true score" (i.e., regression due to measurement error), toward his own genetic value (i.e., $\underline{h}^2(\underline{X} - \bar{\underline{X}}) + \bar{\underline{X}}$, where $\underline{h}^2$ is the heritability of the trait, $\underline{X}$ is the individual's score, and $\bar{\underline{X}}$ is the population mean), toward his own family's mean, toward his social class mean, and toward the mean of the population. [Studies by Lawrence (1931) and by Honzik (1957) show that the IQs of orphanage children and of adopted children regress to some degree toward the IQs of their own biological parents, whom they have never known.] The net effect, in some cases, is progressive increments in scores from early childhood to maturity; and in the other cases, progressive decrements. But regardless of their social class and environmental circumstances, school children who become diagnosed as backward or retarded are known to have shown progressive decrements in their relative standing in mental growth and scholastic achievement (Burt, 1961, p. 636).

Cross-sectional Studies. Cross-sectional age data are quite unsatisfactory

for studying progressive decrement because of selective migration, student turnover related to adult employment trends in the community, over-ageness in later school grades, and other factors correlated with age in the particular school population. Family size is one of the most serious artifacts entering into cross sectional data on age decrement, even when sampling in terms of various demographic factors perfectly matches the population statistics on these factors. For example, in a perfectly random sample of, say, 5-year-olds, smaller size families are over represented, as compared with a random sample of, say, 15-year-olds. And since there is a negative correlation between intelligence test performance and family size, an artifactual age decrement appears in the comparison of 5-year-olds and 15-year-olds (or any two groups of differing age). If the average family size differential across age groups is greater for Negroes than for whites (as is the case), these cross-sectional data will show a larger artifactual age decrement in IQ for Negroes than for whites. It is artifactual because family size is not mainly a causal environmental factor in the negative correlation between family size and IQ. If birth order and family size were major causal factors in IQ variance, then within families later born children should have lower IQs than earlier born, and IQ should decline as a function of the number of previous siblings. McKeown and Record (1971, p. 52), in a properly designed study, have found this not to be the case. They state, "There are very large variations in a general population of births in relation to maternal age and birth order; but these are due to differences between rather than within families, for there is little variation according to birth rank between sibs." The between-families differences reflect demographic factors (such as socioeconomic status and rural vs. urban) related simultaneously to family size and to IQ, thus resulting in a correlation without implying direct causation.

Any one or a combination of these demographic factors can spuriously create the appearance of progressive decrement in one or another subpopulation, or they can counteract and hide a true decrement. All we can be sure of with cross-sectional data is that they reflect demographic rather than strictly psychological phenomena. One can slightly improve psychological inferences from cross-sectional data by taking account of certain demographic variables, but even this leaves much to be desired. For example, Jensen (1971) compared white, Negro, and Mexican groups cross-sectionally on a number of tests at every grade from 1 to 8 in a California school district and found no appreciable evidence of progressive decrement in the two minority groups; he claimed greater validity for this finding by showing that a fine-grained measure of SES and home background factors (Gough's Home Index) did not show any systematic differences across grades. But the question always lingers whether the really relevant demographic variables have been taken into account and, strictly speaking, one is left again with only a demographic rather than a psychological finding.

Longitudinal Studies. Methodologically, longitudinal studies are potentially far superior to cross-sectional studies, but they, too, can suffer some of the same disadvantages to the extent that there is non-random attrition of subjects over the course of time. Duller pupils may drop out of public school and go to private schools, families may move away because of changing employment opportunities in the community, and so on. Longitudinal studies should always note the attrition rate and the relevant characteristics of the subjects that were lost.

Sibling Studies. These have the advantage over cross-sectional and longitudinal studies of not reflecting demographic variables. Progressive decrement is indicated when the standard score difference between younger and older sibs (i.e., the mean of younger minus older within each family) is significantly

greater than zero. To avoid reflecting a demographic feature, however, it is necessary to control for family size. Because of the well-established negative correlation between mental test scores and family size (Anastasi, 1956), there will be more possible sibling pairs contributed by low-scoring families. In other words, low-scoring families, having more children, would be over-weighted in the overall average of the differences between younger and older sibs. This is easily overcome by weighting each family equally in the overall mean, regardless of the number of sibs (and paired differences) in each family. With this control, the sib method is as near to ideal as can be, with the one exception that not a very wide age range can be spanned by this method. Few families today have children spaced more than five or six years apart, and in the vast majority the children are spaced much closer. The sib method controls for genetic factors in the sense that, on average, younger and older sibs do not differ in genotypic value. It also controls largely for environmental factors, in that, on average, younger and older sibs do not enjoy better or worse environments, although it can be argued that first-born children may receive more parental attention, at least in infancy, than later-borns. If this has any lasting advantage, it should counteract the appearance of progressive decrement using the sib method, depending as it does upon the difference between younger and older sibs and the fact that the supposedly advantaged first-born is always the oldest sib. Unless it is taken into account, this effect would work against detection of progressive decrement by the sib method. There is a considerable literature claiming a slight average superiority of the first-born (Altus, 1966). If true, the causes are uncertain, except that they cannot be due to genetic factors. They could involve prenatal as well as postnatal factors, but the latter seem more likely (see Record et al., 1969). If one is comparing progressive decrement in two subpopulations, say, Negroes and whites, by means

of the sib method, and if one can show that the first-born advantage does not occur to a significantly greater degree in one group than in the other, this factor would not obscure a difference in decrement between the two groups.

The mean within-family absolute difference in IQ between all sibs in a sample reflects a composite of both the genetic and the environmental factors that make for sib differences. The mean within-family signed IQ difference between younger and older sibs reflects only the cumulative effect of environmental influences, since there is no known or theoretically expected relationship between birth order and genotypes of siblings within a family. In a large sample, the average of the genotypic values for any given characteristic, like IQ, should be the same for first-borns, second-borns, etc. for families of any given size. Any within-family mean differences according to birth order would therefore reflect nongenetic or environmental factors. In fact, the best controlled studies reveal a small but significant relationship between IQ and birth order when the evidence consists of sibling differences within families, thereby controlling family size and related demographic artifacts. The most definitive study, by Record et al. (1969), found an IQ difference of 1.5 between first and second born, of 0.9 between second and third born, and 0.5 or less between sibs after the third born; at birth rank five and over there is no consistent difference between sibs. Thus, properly used, the sibling method can provide perhaps the best test of age decrement in IQ, certainly more satisfactorily than the cross-sectional method with its plethora of demographic artifacts, and probably more rigorously than the longitudinal method if there has been attrition of the sample.

Specificity of Progressive Decrement. Finally, it should be recognized that finding the presence or absence of progressive decrement in one locality may not generalize to all other localities. Progressive decrement, if it exists

at all, is a population characteristic, like IQ, the birth rate, income or the average daily school attendance. So, theoretically it could vary from one locality to another, from one type of test to another, from one time to another, and from one subpopulation to another. But in any case, progressive decrement cannot simply be presumed to exist. Its existence must of course be demonstrated by some methodologically sound analysis.

The following study illustrates the use of the sibling method for analyzing progressive decrement in white and Negro school populations.

Method

Subjects

The entire Berkeley Unified School District's elementary school (Grades K through 6) population, consisting of some 8,000 children in 17 schools, was given a battery of tests by 20 specially trained testers (12 whites and 8 Negroes). (A separate analysis showed that the race of the examiner had a negligible effect on Lorge-Thorndike scores in both the white and Negro groups [Jensen, in press].) The present analysis is concerned only with the white and Negro subpopulations, which are approximately 60% and 40%, respectively.

From school records and from questionnaires sent to the children's parents, all full sibships within the elementary school population were identified. Half-sibs were also identified but were not included in the present analysis. The presence of half-sibs in the sample would, of course, increase the average difference among children within families. If there was any contamination of the full-sib sample by an admixture of half-sibs falsely identified as full-sibs, it was either of statistically negligible proportions or occurred to an approximately equal extent in the Negro and white samples. One possible check

of this is the full-sib correlation for height. The theoretical genetic correlation for full-sibs is close to .50; for half-sibs it is close to .25. Therefore, if there was an appreciably greater proportion of misidentified half-sibs in the Negro sample (since many more Negro half-sibs were identified in the total population), this should be reflected in a significantly lower nominal sib correlation for Negroes. But in fact this was not the case. The obtained intraclass correlation between full-sibs (uncorrected for attenuation) was .42 for whites and .45 for Negroes. Corrected for unequal standard deviations, but not for attenuation, the intraclass correlations are .44 for whites and .43 for Negroes. Differences between the white and Negro populations in the degree of assortative mating for height or IQ would affect the sib correlations but would have a negligible effect on the mean absolute difference (or within-family variance) between sibs (Crow & Kimura, 1970, pp. 158-9). The mean absolute difference in height between siblings, in standard deviation units based on the total population within 6-month age intervals, is .846 σ for the white group and .856 σ for the Negro group, which is a negligible group difference of .01 σ.

Tests

Several tests of mental abilities and of scholastic achievement were used. All were group-administered to intact classrooms. However, the only tests to be considered for the present discussion are the Lorge-Thorndike IQ tests, because they were the only tests in the battery for which published nationwide age norms are available. Tests for which the national norms are expressed as grade norms rather than age norms (e.g., the Stanford Achievement Tests) are unsuitable for detecting progressive decrement, since the average

age and the age variance in each grade may differ from one school to another, depending upon the school's promotion policies. Though grade norms may be useful to school personnel, they are practically worthless for research in developmental psychology, which requires much more exact quantification of the chief independent variable, viz. the time scale. This is provided only by showing normative scores as a function of chronological age in months rather than by such an arbitrary and ambiguous scale as grade level in school. Local norms are not suitable for progressive decrement analysis, because if there is some demographic shift in the nature of the school population from the younger to the older age groups, the local population age norms will not provide a consistent frame of reference across all ages, and this will introduce some artifact into the magnitude of the younger-older sib differences in the locally standardized scores.

The promotion policy of the Berkeley schools is such that virtually all pupils in the regular classes are in the school grade appropriate for their chronological age. The few exceptions found in the class rolls were administered the particular level of the Lorge-Thorndike intended for their chronological age regardless of their grade placement, so that all the pupils in any given age group were tested on the same level of the Lorge-Thorndike, thereby avoiding any possible measurement artifact due to under-ageness or over-ageness in the white and Negro samples.

Lorge-Thorndike Intelligence Tests. This is a nationally standardized group-administered test of general intelligence. The normative sample was intended to be representative of the nation's school population. It is generally acknowledged to be one of the best standardized paper-and-pencil tests of general intelligence.

The Manual of the Lorge-Thorndike Test states that the test was designed to measure reasoning ability. It does not test proficiency in specific skills taught in school, although the verbal test, from Grade 4 and above, depends upon reading ability. The reading level required, however, is intentionally kept considerably below the level of reasoning required for correctly answering the test questions. Thus the test is essentially a test of reasoning and not of reading ability, which is to say that it would have more of its variance in common with nonverbal tests of reasoning ability than with tests of reading per se.

The tests for Grades K-3 do not depend at all upon reading ability but make use exclusively of pictorial items. The tests for Grades 4-8 consist of two parts, Verbal (V) and Nonverbal (NV). They are scored separately. The chief advantage of keeping the two scores separate is that the Nonverbal scale does not overestimate or underestimate the child's general level of intellectual ability because of specific skills or disabilities in reading.

The following forms of the Lorge-Thorndike Intelligence Tests were used:

Level 1, Form B.	Primary, Nonverbal.	Grades K-1
Level 2, Form B.	Primary, Nonverbal	Grades 2-3
Level 3, Form B.	Verbal and Nonverbal	Grades 4-6.

The "consumable" form of the test was used to obviate separate answer sheets and the added difficulty they may involve for the testees.

Results and Discussion

Raw Scores as Function of Age

Table 1 shows the white and Negro sample sizes within each six months age interval on each of the Lorge-Thorndike tests.

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Insert Table 1 about here

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Figure 1 shows the raw test scores (i.e., number of items right) on each of the forms as a function of age. It can be seen that within each form the scores increase quite linearly with age and that the slopes of the increase are very nearly parallel in the white and Negro samples. This parallelism suggests the absence of any progressive decrement in the Negro sample, relative to the white. But it is inconclusive for two reasons: (a) since these are cross-sectional data, the population may shift from one age to another, and (b) the wide separation of the white and Negro means (amounting to about 20 IQ points) at all ages indicates that the discriminating items in a given test are different, on the whole, for whites and Negroes. It cannot be presumed that score increments in the first half of the test are equal to those in the second half. Therefore the parallelism seen in Figure 1, strictly speaking, is uninterpretable with respect to the possible

Table 1

Total Number of White (W) and Negro (N) Pupils in Each Six-Month Age Group on the Lorge-Thorndike IQ Test

Age	5-1/2		6		6-1/2		7		7-1/2		8		8-1/2		9		Total	
Test	W	N	W	N	W	N	W	N	W	N	W	N	W	N	W	N	W	N
Primary	274	198	289	191	294	137	251	120	321	193	298	219	304	202	275	187	2,306	1,447

Age	9-1/2		10		10-1/2		11		11-1/2		12							
Intermediate	W	N	W	N	W	N	W	N	W	N	W	N					W	N
Verbal	265	156	289	150	271	222	302	201	322	198	262	177					1,711	1,104
Nonverbal	263	175	308	168	271	231	307	188	334	194	256	183					1,748	1,139

presence or absence of a progressive decrement in the Negro sample.

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Insert Figure 1 about here

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Sibling Analysis

The sibling analysis satisfies the requirements for detecting progressive decrement: (a) it assures comparisons between younger and older children in the same population at all age levels, since all the comparisons are within families, and (b) the age differences in IQ are expressed in terms of nationally standardized age norms, and the normative samples were specially selected to be demographically homogeneous across the entire range of these tests.

Since the average number of silbings taking any particular form of the Lorge-Thorndike test differs in the white and Negro families (2.25 and 2.35, respectively), it is necessary to make the average sibling IQ difference (younger-older sib) independent of family size. Since the number of paired sib comparisons within a family is $(N^2-N)/2$, where N is the number of sibs in the family, larger families would disproportionately weight the mean sib IQ difference, thereby confounding mean sib difference with family size. To overcome this, one simply obtains the mean sib IQ difference within each family and averages these mean differences over all families in each racial group.

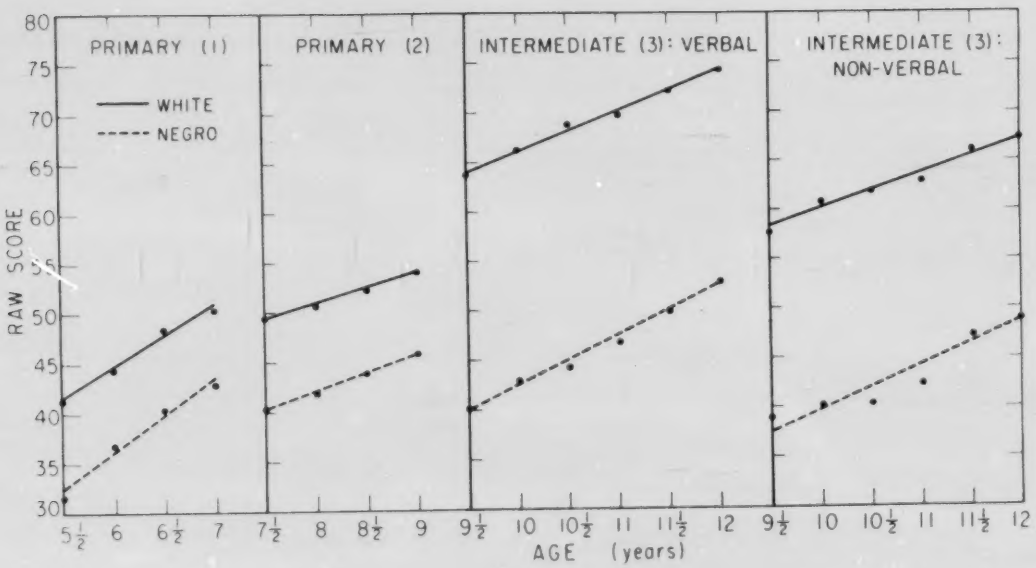

Fig. 1 Raw scores (i.e. number right) of White and Negro children on Primary and Intermediate forms of the Lorge-Thorndike Intelligence Test as a function of chronological age. The Ns for each data point are given in Table 1.

Table 2 shows the mean IQ differences between younger and older siblings

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Insert Table 2 about here

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within families, as well as the mean age differences between the older and younger sibs. The differences are presented for each of the four possible combinations of younger-older × sex, and for all younger-older sibs regardless of sex. Sib differences are given for each form of the test separately, which restricts the number and age range of sib differences, and also across the Primary and Intermediate (Verbal and Nonverbal) forms, in order to increase the potential number of sib comparisons. Sib IQ differences that cross the Primary and Intermdiate forms, of course, involve some risk of reflecting a possible change in the factorial composition of the different test forms. The test formats and style differ: the Primary material is somewhat less abstract and requires no reading, the Intermediate Verbal test involves reading, the Nonverbal involves abstract figural material.

A progressive age decrement in IQ, relative to the normative population, would be indicated by a positive difference between the IQs of younger and older (i.e., Y-O) sibs. The differences which are significant at or beyond the 5 percent level are indicated by a, b, and c for the 5%, 2.5% and 1% levels, respectively. (The significance of the Y-O sib difference from zero was determined by a one-tail t test, since only the hypothesis $Y-O > 0$ would be consistent with a progressive decrement.

We are concerned primarily with evidence of progressive decrement in the Negro group. It can be seen that for the Negroes there is a significant

Table 2

Mean Sibling Difference (Younger-Older) in Lorge-Thorndike IQ

Test Form Taken By		IQ Difference (Y-O) White		IQ Difference (Y-O) Negro		Age Difference (O-Y) in Months White		Age Difference (O-Y) in Months Negro		t Test[1] of Age Difference	Absolute Difference in IQ White		Absolute Difference in IQ Negro		t Test[2] of Absolute Difference in IQ	Number of Families White	Number of Families Negro
Younger Sib	Older Sib	Mean	SD	Mean	SD	Mean	SD	Mean	SD		Mean	SD	Mean	SD			
YOUNGER BROTHER - OLDER BROTHER																	
Primary	Primary	3.62[b]	16.51	.43	12.41	23.19	9.12	21.55	9.12	1.05	12.81	11.28	10.26	7.57	1.50	83	58
Verbal	Verbal	-5.05	19.30	6.94	18.51	19.46	5.54	18.50	5.79	0.60	16.40	12.05	16.06	11.53	0.12	41	18
Primary	Verbal	-3.77	16.94	3.22[c]	15.32	30.39	13.56	27.90	12.41	1.71[a]	14.11	10.90	12.79	9.71	1.14	241	125
Nonverbal	Nonverbal	-3.34	13.58	-2.71	20.88	19.66	5.05	17.62	6.72	1.37	11.03	8.59	17.12	12.25	-2.32[a]	39	24
Primary	Nonverbal	-4.86	15.71	-1.21	16.46	30.56	13.70	27.41	12.35	2.22[b]	12.99	10.56	13.40	10.25	-0.37	241	136
YOUNGER SISTER - OLDER BROTHER																	
Primary	Primary	-0.84	15.56	1.41	16.95	21.12	7.05	20.37	8.98	0.52	12.85	8.89	13.34	10.64	-0.28	74	49
Verbal	Verbal	0.80	16.91	4.76	16.21	18.80	14.67	5.50	3.73	3.15[c]	13.40	10.34	14.19	9.17	-0.30	50	21
Primary	Verbal	-2.85	15.88	1.77	17.23	29.22	13.21	25.90	12.75	2.27[b]	13.40	9.16	14.02	10.42	-0.58	237	120
Nonverbal	Nonverbal	0.19	16.97	-6.60	15.89	19.37	5.96	15.62	3.54	2.94[c]	14.15	9.38	14.29	9.58	-0.62	48	26
Primary	Nonverbal	-3.35	15.74	-2.77	18.19	30.05	13.95	26.30	12.75	2.57[c]	13.24	9.39	14.96	10.96	-1.60	247	133
YOUNGER BROTHER - OLDER SISTER																	
Primary	Primary	1.66	15.84	3.55	15.07	21.30	7.07	19.93	6.76	1.11	12.67	9.77	11.79	10.04	0.50	96	47
Verbal	Verbal	-0.56	12.76	-0.17	14.01	18.98	5.59	17.44	6.14	0.94	10.02	7.91	12.11	7.05	-0.96	41	18
Primary	Verbal	-2.77	14.87	1.48	14.68	28.80	12.34	26.75	13.21	1.43	12.49	9.26	11.80	9.03	-0.66	258	115
Nonverbal	Nonverbal	-2.74	13.77	-3.77	17.73	19.13	5.93	17.55	6.26	0.98	11.16	8.53	15.05	10.16	-1.59	38	22
Primary	Nonverbal	-4.31	15.19	-1.07	15.55	28.71	12.13	26.29	12.92	1.74[a]	13.21	9.34	12.44	9.54	0.73	255	115
YOUNGER SISTER - OLDER SISTER																	
Primary	Primary	-0.04	14.93	1.27	11.75	21.07	7.36	21.01	8.49	0.05	11.56	9.46	10.34	6.10	0.81	75	51
Verbal	Verbal	1.45	16.83	3.55	12.76	20.06	4.77	18.23	6.19	1.22	13.58	10.05	9.64	9.08	1.46	31	22
Primary	Verbal	-4.48	16.39	-0.39	13.60	30.33	13.35	27.91	11.97	1.66[a]	13.98	10.30	11.12	8.22	2.63[c]	196	127
Nonverbal	Nonverbal	-1.59	16.31	6.38	16.41	20.76	4.34	19.22	6.15	1.00	12.97	10.02	15.50	8.69	-0.89	29	18
Primary	Nonverbal	-6.41	15.16	-2.28	14.67	30.57	13.18	27.72	12.18	1.95[a]	13.79	9.65	12.84	8.27	0.91	199	124
ALL YOUNGER - OLDER SIBLINGS																	
Primary	Primary	1.72[a]	15.44	1.62	14.03	21.62	7.35	20.55	7.87	1.48	12.41	9.90	11.61	8.69	0.89	295	174
Verbal	Verbal	-0.41	16.65	3.94[b]	15.93	19.36	5.12	17.20	5.74	2.87[c]	13.10	10.45	13.24	9.70	-0.09	155	75
Primary	Verbal	-3.19	15.32	1.64[b]	15.11	29.72	12.34	27.11	12.30	3.34[c]	13.47	9.48	12.73	9.27	1.25	735	375
Nonverbal	Nonverbal	-1.30	15.15	-2.05	18.82	19.73	5.21	17.39	5.83	3.13[c]	12.32	8.95	15.81	10.46	-2.27[a]	148	83
Primary	Nonverbal	-4.53	14.98	-1.36	15.84	30.02	12.48	26.99	12.36	3.90[c]	13.44	9.42	13.67	9.55	-0.39	741	393

[1] One-tail t test.

[2] Two-tail t test.

[a] Significant at 5 percent level.

[b] Significant at 2.5 percent level.

[c] Significant at 1 percent level.

Y-O difference involving only the Verbal IQ, which is significant at the 2.5% level for the combined sexes, and at the 1% level for the younger brother-older brother group. It is not significant for the other three sex combinations. The discrepancies in significance level for the various mean sib differences involving Verbal IQ appear to be more related to differences in sample sizes than to magnitudes of the differences themselves. The fact that the Y-O sib difference appears as significant for the combined sexes, however, means that it must be interpreted as a real effect, albeit not of consistent magnitude for all sex combinations of the Y-O sib differences. The Verbal IQ, it should be noted, is the only form of the Lorge-Thorndike test that involves reading comprehension.

The Nonverbal IQ in the Negro group, on the other hand, shows no evidence of a progressive decrement.

The white group shows no decrement in either the Verbal or Nonverbal IQ, although there is a slight but significant Y-O sib difference on the Primary test, attributable to the brother-brother comparison.

Thus, the present evidence for a progressive IQ decrement in the Negro group is confined to the Verbal IQ, and it is a small effect in relation to the mean White-Negro IQ differences (Primary 18.05, Verbal 21.38, Nonverbal 21.63).

Table 2 also shows the mean absolute IQ difference between sibs within families, that is to say, the mean difference between sibs regardless of whether the difference is positive or negative. While the overall mean signed difference between younger and older sibs can reflect only nongenetic or environmental factors (since there is no theoretical basis for assuming a correlation between genotypic values and birth order), the mean absolute difference reflects <u>all</u> sources of difference between siblings, genetic and environmental, as well

as errors of measurement. It is therefore instructive to compare the mean absolute sib differences in the white and Negro groups. If it is hypothesized that the distributions of genotypes for IQ are the same in both racial groups, then any racial group disparity in the absolute difference between sibs would have to reflect nongenetic influences on IQ. All factors that potentially could affect IQ are reflected in the absolute sib difference--sex differences, age differences, birth order differences, etc.

As shown in Table 2, a two-tail t test of the White-Negro difference in the mean absolute sib IQ differences reveals mostly nonsignificant racial differences. The couple of differences that are significant in two of the sex combinations are of opposite sign and occur for different tests. Any interpretation of them, against the background of so many nonsignficant differences, would necessarily be very tenuous and speculative. It seems reasonable to conclude from these data that, in general, the mean absolute sib IQ difference is about the same in the white and Negro groups. This finding implies more or less equal influence in the two racial groups of the sum total of environmental factors contributing to within-family IQ differences. It is therefore inconsistent with the cumulative deficit hypothesis, which should predict larger absolute differences between siblings' IQs, since the older sibs, on the average, should have lower IQs--a source of within-family variance that would not exist in the white normative population.

Correlation Between Age Difference and IQ Difference. It also follows from the cumulative deficit hypothesis that there should be a positive correlation between the sib age difference (O-Y) and the sib IQ difference (Y-O). To test this hypothesies, Pearson's r was computed between age difference (O-Y) and IQ difference (Y-O) within each of the four possible sex combinations

of sibs and for each pair of tests involved. So that family size would not be confounded in this correlation, each family is weighted equally in determining the r, regardless of the number of sib pairs within each family. The rs were tested for significance by a one-tail t test, since only a positive r is consistent with the progressive decrement hypothesis. The results are shown in Table 3. There is only one significant (0.5% level) correlation in the Negro

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Insert Table 3 about here

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group and it occurs only on the Verbal IQ in the brother-brother comparison. The r is negligible (and at times reversed in sign) in all the other comparisons. The one significant r out of a possible twenty could well be a fluke, but the fact that it involves the Verbal IQ at least makes it somewhat consistent with the evidence in Table 2 for a progressive decrement in Verbal IQ. However, the hypothesized effect shows up not at all significantly in the correlation for all Negro siblings combined (see last two columns of Table 3).

Family Size and Sib IQ Difference. The fact that there are more children in the Negro than in the white families could affect the results of the preceding analyses if there were a significant correlation between the sib IQ difference and the number of children in the family. If such a correlation exists, it would not be proper, however, statistically to control or partial out the variable of family size in the preceding analyses, since family size could itself be a causal factor in the direction and magnitude of sibling differences. That this is not the case, however, is shown by the consistently negligible correlations between family size (i.e., total number of children

Table 3

Correlation Between Sibling IQ Difference (Younger-Older) and

Sibling Age Difference (Older-Younger) in Months

Test Form Taken By		Brother - Brother				Sister - Brother[a]				Brother - Sister[a]				Sister - Sister				All Siblings			
		White		Negro		White		Negro		White		Negro		White		Negro		White		Negro	
Younger Sib	Older Sib	r[b]	N	r	N	r	N	r	N	r	N	r	N	r	N	r	N	r	N	r	N
Primary	Primary	.16	83	.11	58	-.19	74	-.09	49	-.07	96	-.11	47	.04	75	.08	51	.03	295	-.02	174
Verbal	Verbal	-.19	41	.54**	18	-.24	50	-.15	21	.05	41	-.13	18	-.05	31	.10	22	.14*	155	.11	75
Primary	Verbal	-.06	241	.08	125	-.10	237	-.03	120	-.16	258	.07	115	-.12	196	-.07	127	-.11	735	.00	375
Nonverbal	Nonverbal	.24	39	.22	24	-.06	48	-.38	26	-.02	38	-.08	22	-.22	29	.01	18	-.01	148	.07	83
Primary	Nonverbal	-.10	241	.01	136	-.19	247	-.06	133	-.12	255	-.02	115	-.17	199	-.20	124	-.14	741	-.05	393

[a] The first one listed is the younger.

b Since only a positive r is consistent with the progressive decrement hypothesis, only positive values of r are tested for statistical significance by a one-tail t test.

[c] N is in all cases the number of families represented in the correlation. Each family, regardless of its number of siblings, is weighted equally in determining the correlation coefficient (Pearson r).

* Significant at 2.5 per cent level by one-tail test.

** Significant at 0.5 per cent level by one-tail test.

in the family) and sib IQ difference--both the signed Y-O difference and the absolute difference, presented in Table 4. Only one out of 20 of the rs is

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Insert Table 4 about here

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significant at the 5% level, which is no more than would be expected by chance. The correlations were also obtained within each of the four sex combinations of sibs, and none of the correlations even approached significance. It seems safe to conclude that family size is an unimportant factor in sibling IQ differences, both for whites and Negroes.

Effect of Birth Order on IQ. If there were a significant effect of birth order on IQ and this effect interacted significantly with race, it would complicate or obfuscate the interpretation of the foregoing results. For example if the earlier born (i.e., older) sibs had higher IQs than the later born, this would counteract or mask the appearance of a progressive decrement as evidenced by the younger-older sib IQ difference. And if there were a significant interaction of race × birth order, the degree of masking of the progressive decrement would be different for Negroes and whites.

To examine this possibility, the effects of birth order on IQ and the interaction of the birth order effect with race were tested by an analysis of variance. So as not to confound birth order effect with family size, the analysis of variance was performed separately for each family size, using all families having at least two children and at most six. Families of more than six children were too few to warrant statistical analysis. For each family

Table 4

Correlation Between Sibling IQ Difference (Younger-Older) and Number of Children in Family[a]

Test Form Taken by Younger Sib	Test Form Taken by Older Sib	Number of Families White	Number of Families Negro	Correlation Sib IQ Difference × No. Children in Family White	Correlation Sib IQ Difference × No. Children in Family Negro	Correlation Absolute Sib IQ Difference × No. Children in Family White	Correlation Absolute Sib IQ Difference × No. Children in Family Negro
Primary	Primary	295	174	-.021	.077	-.041	-.075
Verbal	Verbal	155	75	-.030	.072	-.007	-.010
Primary	Verbal	735	375	-.061	.037	.044	-.068
Nonverbal	Nonverbal	148	83	-.127*	-.046	-.053	-.033
Primary	Nonverbal	741	393	-.055	-.037	.015	.010

[a] Number of Children in family is all children, including those who were not tested in this study. Mean number of children per family: White = 3.05, σ = 1.41; Negro = 3.39, σ = 2.33. (Note: Single-child families are necessarily excluded from this analysis.)

* Significant at the 5 percent level, two-tail test.

size, a two-way ANOVA was used, yielding main effects for Race and Birth Order and the Race × Order interaction. The results of the ANOVAs are summarized in Table 5, which gives the *F* value, the degrees of freedom, and the exact *P* values for each *F*.

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Insert Table 5 about here

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It can be seen that the main effect of race is highly significant throughout all sizes of family. The birth order effect is surprisingly small, and in fact attains significance (for both Verbal and Nonverbal IQ) only in 4-child families, in which the first born children have slightly higher IQs than later born. In no instance, however, is there a significant interaction of Race × Birth Order, and in fact the exact *P* values show that this interaction does not even approach significance. The same kind of ANOVA was performed on each of the four possible sex combinations of sibs, all with highly similar results. Therefore, the effects of birth order on all the preceding analyses are almost certainly negligible.

Further evidence of the small effect of birth order on IQs in this study can be had from the correlations between birth order and IQ, with family size partialled out of the correlation. Table 6 shows the zero-order correlations of IQ with family size and birth order. It is noteworthy that the

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Insert Table 6 about here

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Table 5

Analysis of Variance of Verbal and Nonverbal IQ as a Function of Race, Birth Order, and the Interaction of Race and Birth Order for Families with Two to Six Children

Family Size	Race		Birth Order		Interaction (R × O)	
	F[a]	df	F[b]	P	F[b]	P
			Verbal IQ			
2	471.92	1/1264	.07	.78	2.31	.13
3	681.18	1/1241	.21	.81	2.02	.13
4	399.33	1/823	2.55	.05	1.00	.39
5	146.28	1/340	1.20	.31	1.15	.33
6	48.31	1/151	1.28	.27	.78	.57
			Nonverbal IQ			
2	485.91	1/1264	.01	.93	.65	.42
3	653.95	1/1241	.43	.65	.59	.55
4	374.20	1/827	4.19	.01	.44	.72
5	122.76	1/343	.20	.93	.77	.54
6	42.43	1/155	1.03	.40	.65	.66

[a] All F's significant at $p < .0001$.

[b] The df numerator is 1 less than family size, the denominator is same as under Race.

Table 6

Correlations[a] of Lorge-Thorndike IQ With Family Size and Birth Order in White and Negro Groups

Test	Family Size						Birth Order						Sample Size					
	Males		Females		Total		Males		Females		Total		Males		Females		Total	
	W	N	W	N	W	N	W	N	W	N	W	N	W	N	W	N	W	N
Primary	-15[d]	-04	-09[c]	-10[c]	-12[d]	-07[b]	-09[c]	00	-09[c]	-03	-09[d]	-01	926	502	835	514	1761	1016
Primary or Verbal	-11[d]	-05	-11[d]	-07[b]	-11[d]	-06[c]	-09[d]	-01	-13[d]	-03	-11[d]	-02	1527	779	1413	816	2940	1595
Primary or Nonverbal	-10[d]	-02	-08[d]	-05	-09[d]	-03	-08[d]	-03	-11[d]	-04	-09[d]	-04	1533	806	1420	809	2953	1615
Verbal	-12[d]	-04	-19[d]	-07	-16[d]	-05	-11[c]	-03	-18[d]	-04	-14[d]	-03	601	277	578	302	1179	579
Nonverbal	-14[d]	-02	-13[d]	-05	-14[d]	-04	-08[b]	-07	-11[c]	-07	-09[d]	-07	607	304	586	295	1193	599

[a] Decimals omitted.

[b] Significant at $p < .05$.

[c] Significant at $p < .01$.

[d] Significant at $p < .001$.

correlation between IQ and family size is consistently greater for whites than for Negroes. As in many other studies reported in the literature on IQ and family size, all the correlations are negative, but here they are of somewhat lesser magnitude than those usually reported, which average close to -.30. Part of the reason may be that the present analysis is limited to family sizes of from two to six children.

The correlations of IQ with birth order are all quite small. But the birth order × IQ correlations in Table 6 are confounded by the variable of family size. What we actually wish to know is the correlation between IQ and birth order independently of family size. This is given by the partial correlation between IQ and birth order, statistically removing the variable of family size. These partial correlations are shown in Table 7. Despite the large Ns

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Insert Table 7 about here

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all the partial rs are nonsignificant, with the exception of white females, with $r = -.07$, $p < .05$. Since the correlations in the Negro group center closely around zero, it surely cannot be argued that the failure of the younger minus older sibling difference to reveal any evidence of a progressive IQ decrement in the Negro group is due to a masking of the decrement by the effect of birth order on IQ.

Only Child versus Siblings. Finally, we must inquire as to whether the omission of subjects who are only-children from all the preceding analyses based on sibling differences seriously biases the sample so that it is not

Table 7

Correlation[a] Between Birth Order and Family Size, and Partial Correlation[a] Between Birth Order and IQ With Family Size Partialed Out

	Correlations						Sample Size					
	Males		Females		Total		Males		Females		Total	
	W	N	W	N	W	N	W	N	W	N	W	N
Birth Order × Family Size	72	78	73	49	74	59	1574	829	1457	845	3031	1674
Partial r of Birth Order × IQ												
Primary	03	05	-04	03	00	04	926	502	835	514	1761	1016
Primary or Verbal	-03	05	-07[c]	01	-05[c]	02	1527	779	1413	816	2940	1595
Primary or Nonverbal	-02	-02	-07[c]	-02	-04[b]	-02	1533	806	1420	809	2953	1615
Verbal	-03	00	-06	-01	-06[b]	00	601	277	578	302	1179	579
Nonverbal	03	-09	-01	-05	01	-06	607	304	586	295	1193	599

[a]Decimals omitted.

[b]Significant below $p < .05$.

[c]Significant below $p < .01$.

representative of the whole Berkeley school population as regards IQ. Only-children comprise about 7 percent of the total white and about 11 percent of the total Negro school population in Berkeley. The mean IQ differences between only-children and children with sibs are shown in Table 8. Only one

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Insert Table 8 about here

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of the differences is just barely significant at the 5 percent level; that is, Negro only-children average slightly higher IQs than Negro children with sibs, an effect which is significant only for Verbal IQ. Thus, there is practically no basis for assuming that the IQs of the sibling sample are unrepresentative of the total school population.

Summary and Conclusions

Cumulative deficit refers to the hypothesis which attempts to explain the purported increasing disparity throughout the ages from early childhood to maturity between the average mental and scholastic achievement test scores of Negroes and whites, or in general, between more and less culturally and environmentally disadvantaged segments of the population. The existence of the phenomenon supposedly in need of explanation, here called progressive decrement (in rank, percentile, or standardized score), has not been unequivocally established in any samples of the U.S. Negro population. Most of the data and analyses usually presented as evidence for a progressive decrement are riddled with artifact. The most common method--Negro-white comparisons of cross-sectional age samples--confounds demographic and psychological variables; the results of

Table 8

IQ Difference Between All Only-Children and All Children with Siblings in Total White and Negro Groups

	White				Negro			
	Number				Number			
IQ Test	Only	Sibs	IQ Diff.[a]	t	Only	Sibs	IQ Diff.[a]	t
Primary	165	1761	-1.18	-0.93	150	1016	1.48	1.24
Primary or Verbal	249	2940	-0.97	-0.91	205	1595	2.10	1.99*
Primary or Nonverbal	251	2953	-2.00	-1.90	205	1615	1.77	1.70
Verbal	84	1179	0.87	0.50	55	579	3.53	1.61
Nonverbal	86	1193	-1.67	-0.99	55	599	3.77	1.90

[a] Mean IQ of only-children minus mean IQ of siblings.

* Significant at 5 percent level.

such studies are conflicting, ambiguous, and generally untrustworthy.

Longitudinal studies of standardized test-score changes with age are scarce, unfortunately, for they are much less liable to demographic selection artifacts, unless there is significant nonrandom attrition of the sample over time, which would introduce many of the same artifacts that vitiate cross-sectional studies. The few existing longitudinal studies are quite inconclusive with respect to the progressive decrement phenomenon.

The sibling method, which is based on the average within-family sib difference in test scores between younger and older sibs, overcomes these artifacts and permits perhaps the most satisfactory test of the existence of a progressive decrement. This method is illustrated here by making all possible sib IQ comparisons within the Negro and white populations (40% and 60%, respectively) in all the elementary grades (K to 6) of a California school district. The sibling method gains in rigor and weight when the variables of family size and birth order are properly taken into account, as was done in the present study.

The sibling analyses revealed evidence of a small but statistically significant progressive decrement in the Negro group only for the Lorge-Thorndike Verbal IQ, and the effect is more evident in boys than in girls. There is not the slightest evidence of a progressive decrement in Negroes' Nonverbal IQ, which, interestingly, is slightly lower than their Verbal IQ. Of the three forms of the Lorge-Thorndike Intelligence Tests used in this study, the only one showing any sign of a progressive decrement at all is the Verbal test, which requires reading. It seems a likely conjecture that the progressive decrement involves reading skills per se, rather than the abilities essentially defined as intelligence. In any case, the small magnitude of the Verbal IQ decrement, as well as the total absence of the hypothesized decrement on the

Nonverbal tests, surely renders the cumulative deficit hypothesis, at least in the age range of 5 ot 12, an unlikely explanation of the more than one standard deviation IQ difference between the white and Negro means.

The main expectations that should follow from the cumulative deficit theory, or from the hypothesis that environmental effects on mental development cumulate like compound interest, when rigorously tested, are not, in general, borne out by the evidence. If Negro IQ were significantly depressed by lack of proper stimulation in the home environment, by poorer schooling, by lower teacher expectations, by cumulative effects of repeated frustrations of failures in the school setting, and by decreasing motivation and cooperativeness in the learning and testing situation with each successive year in school, then we should indeed expect to find a progressive decrement in IQ with increasing age, in accordance with the cumulative deficit hypothesis. The complete failure of the data to support this expectation for all the IQ tests, except the one involving reading, must imply that the hypothesized cumulative effect of environmental disadvantages either does not exist or has made all of its impact prior to about five years of age. Yet it would seem unlikely, if environmental effects on intellectual development act cumulatively like compound interest, that such cumulative effects would not continue beyond age five.

The results of the present study, in addition to the lack of contradictory evidence in the previous research literature, support the conclusion that the causes of the Negro IQ deficit, whatever they might be, must be sought in factors whose influences are already fully established before school age.

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Footnotes

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[2] Requests for reprints should be sent to the author, Institute of Human Learning, University of California, Berkeley, CA 94720.

[3] When the same children were tested on nonverbal performance tests, there was much less decline in scores and the average IQ was 13 points higher. Fewer than 1 in 10 obtained performance IQs below 70 (Gaw, 1925). This dissimilarity of the English canal boat children's test scores from the scores of American Negroes, who generally obtain slightly lower scores on nonverbal performance tests than on verbal tests (Shuey, 1965, p. 504), brings into question the relevance of the canal boat findings for understanding the Negro IQ deficit.